



(51) International Patent Classification:

A23L 1/305 (2006.01) A23L 1/304 (2006.01)  
A23L 2/66 (2006.01)

(21) International Application Number:

PCT/US2015/039381

(22) International Filing Date:

7 July 2015 (07.07.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/021,991 8 July 2014 (08.07.2014) US

(71) Applicant: ABBOTT LABORATORIES [US/US]; Dept.  
377/AP6A-1, 100 Abbott Park Road, Abbott Park, Illinois  
60064 (US).

(72) Inventors: BLUMBERG, Rachel; 5332 A Drumcally  
Lane, Dublin, Ohio 43017 (US). DEWILLE, Normanella;  
2580 Clairmont Court, Columbus, Ohio 43220 (US).  
WEARLY, Douglas; 8270 Crete Lane, Blacklick, Ohio  
43004 (US). JOHNS, Paul; 3115 Rightmire Boulevard,  
Columbus, Ohio 43221 (US).

(74) Agents: BRADY, J et al.; Abbott Nutrition a Division of,  
Abbott Laboratories, 3300 Stelzer Road, Dept 108140  
RP3-2, Columbus, Ohio 43219 (US).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,  
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,  
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,  
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,  
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,  
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,  
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,  
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,  
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every  
kind of regional protection available): ARIPO (BW, GH,  
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,  
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,  
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,  
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,  
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,  
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: NUTRIENT DELIVERY SYSTEM FOR ENHANCED NUTRIENT UPTAKE

(57) Abstract: A nutrient delivery system includes a protein system, calcium, zinc, and iron. The protein system includes a calcium binding protein in an amount of 40% to 75% by weight of the protein system, a zinc binding protein in an amount of 10% to 30% by weight of the protein system, and an iron binding protein in an amount of 10% to 30% by weight of the protein system. The calcium binding protein and the calcium are present in a weight ratio of 13:1 to 25:1, the zinc binding protein and the zinc are present in a weight ratio of 6:1 to 900:1, and the iron binding protein and the iron are present in a weight ratio of 5.4:1 to 800:1.



**NUTRIENT DELIVERY SYSTEM FOR ENHANCED NUTRIENT UPTAKE****CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims priority to and any benefit of U.S. Provisional Application No. 62/021,991, filed July 8, 2014, the content of which is incorporated herein by reference in its entirety.

**FIELD OF THE DISCLOSURE**

[0002] The present disclosure relates to a nutrient delivery system for enhanced nutrient uptake, and, in particular, to a nutrient delivery system containing a protein system, calcium, zinc, and iron.

**BACKGROUND OF THE DISCLOSURE**

[0003] Nutritional products, including supplements and nutritional compositions, often contain various protein sources. Selection of protein sources is generally focused on providing a nutritional product with a desired level of dietary amino acid supplementation. Consideration of other factors, such as the ability of selected proteins to facilitate nutrient uptake, may provide for better nutritional products.

**SUMMARY OF THE DISCLOSURE**

[0004] Disclosed herein is a nutrient delivery system. The nutrient delivery system includes a protein system, calcium, zinc, and iron. The protein system includes a calcium binding protein in an amount of 40% to 75% by weight of the protein system, a zinc binding protein in an amount of 10% to 30 % by weight of the protein system, and an iron binding protein in an amount of 10% to 30 % by weight of the protein system. The calcium binding protein and calcium are present in a weight ratio of 13:1 to 25:1, the

zinc binding protein and zinc are present in a weight ratio of 6:1 to 900:1, and the iron binding protein and iron are present in a weight ratio of 5.4:1 to 800:1.

### **DETAILED DESCRIPTION OF THE DISCLOSURE**

[0005] The present disclosure involves a nutrient delivery system which includes a protein system, calcium, zinc, and iron. The essential features of the nutrient delivery system, as well as some of the many optional variations and additions, are described in detail hereafter.

[0006] The term “nutritional composition” as used herein, unless otherwise specified, refers to nutritional liquids and nutritional solids, including powders, which may be reconstituted to form a nutritional liquid, and are suitable for oral consumption by a human.

[0007] All percentages, parts and ratios as used herein, are by weight of the total product, unless otherwise specified. All such weights as they pertain to listed ingredients are based on the active level and, therefore, do not include solvents or by-products that may be included in commercially available materials, unless otherwise specified.

[0008] All references to singular characteristics or limitations of the present disclosure shall include the corresponding plural characteristic or limitation, and vice versa, unless otherwise specified or clearly implied to the contrary by the context in which the reference is made.

[0009] All combinations of method or process steps as used herein can be performed in any order, unless otherwise specified or clearly implied to the contrary by the context in which the referenced combination is made.

[0010] The various embodiments of products of the present disclosure may also be substantially free of any optional or selected essential ingredient or feature described herein, provided that the remaining product still contains all of the required ingredients or

features as described herein. In this context, and unless otherwise specified, the term “substantially free” means that the selected product contains less than a functional amount of the optional ingredient, typically less than about 1%, including less than about 0.5%, including less than about 0.1%, and also including zero percent, by weight of such optional or selected essential ingredient.

[0011] The products may comprise, consist of, or consist essentially of the essential elements of the products as described herein, as well as any additional or optional elements described herein or otherwise useful in nutritional product applications.

[0012] Disclosed herein is a nutrient delivery system. The nutrient delivery system includes a protein system, calcium, zinc, and iron. The protein system includes a calcium binding protein, a zinc binding and an iron binding protein.

[0013] The calcium binding protein, zinc binding protein, and iron binding protein may be present in the protein system in any amount that allows for the body to make effective use of the calcium, zinc, and iron present in the body and provided as part of the nutrient delivery system. Effective ranges for the binding proteins in the protein system include 40% to 75% calcium binding protein, 10% to 30% zinc binding protein, and 10% to 30% iron binding protein, each by weight of the protein system. In some embodiments, the calcium binding protein is present in an amount of 45% to 75%, including 50% to 70%, including 55% to 65%, and including 60%, by weight of the protein system. In some embodiments, the zinc binding protein is present in an amount of 10% to 25%, including 15% to 25%, including 18% to 22%, and including 20%, by weight of the protein system. In some embodiments, the iron binding protein is present in an amount of 10% to 25%, including 15% to 25%, including 18% to 22%, and including 20%, by weight of the protein system. As described in further detail below and shown in Example 7, the relative concentrations of the binding proteins may contribute to the ability of the nutrient delivery system to provide essential amino acids, to support the uptake of minerals, or both.

[0014] In some embodiments, the relative amounts of calcium binding protein, zinc binding protein, and iron binding protein of the nutrient delivery system provide a complete source of essential amino acids, *i.e.*, amino acids that animals must obtain from the diet. In some embodiments, the nutritional delivery system provides a complete source of essential amino acids when the concentrations of the amino acids meet the 2013 minimum protein quality requirements for adults as established by the Food and Agriculture Organization of the United Nations (FAO minimum), as shown in Table 1, below.

[0015] The calcium, zinc, and iron binding proteins can be obtained from any food source and can be any binding protein that effectively binds each of the respective minerals. Non-limiting examples of calcium, zinc, and iron binding proteins include casein, rice protein, and pea protein, respectively. As also shown in Table 1, with amino acid deficiencies in bold, casein, but neither rice protein, nor pea protein, provides a complete source of essential amino acids. While casein provides a complete source of essential amino acids, as shown in Example 7, use of multiple mineral binding proteins provides improved mineral uptake relative to a single mineral binding protein. For example, rice protein is more effective than casein protein at binding zinc, and pea protein is more effective than casein protein at binding iron. Thus, including rice and pea proteins in a nutritional product with casein protein will provide for greater uptake of zinc and iron, respectively, than a nutritional product with casein protein alone.

Table 1. Digestible essential amino acid concentrations, mg/g protein

| <b>Essential amino acid</b> | <b>FAO minimum<sup>a</sup></b> | <b>Casein protein<sup>b</sup></b> | <b>Pea protein<sup>b</sup></b> | <b>Rice protein<sup>b</sup></b> |
|-----------------------------|--------------------------------|-----------------------------------|--------------------------------|---------------------------------|
| His                         | 20                             | 30                                | 22                             | <b>19</b>                       |
| Ile                         | 32                             | 55                                | 38                             | 43                              |
| Leu                         | 66                             | 96                                | 67                             | 75                              |
| Lys                         | 57                             | 79                                | 68                             | <b>34</b>                       |
| Met + Cys                   | 27                             | 32                                | <b>23</b>                      | 39                              |
| Phe + Tyr                   | 52                             | 109                               | 73                             | 95                              |
| Thr                         | 31                             | 43                                | 32                             | 31                              |
| Trp                         | 8.5                            | 13                                | 10                             | 11                              |
| Val                         | 43                             | 71                                | 43                             | 58                              |

<sup>a</sup> FAO Food and Nutrition Paper 92, 2013, Table 5, page 29

<sup>b</sup> digestibility values from Gaudichon et al., *Gastroenterol*, 123 (2002) 50-59

[0016] By contrast, as shown in Table 2 in the Examples section, the protein systems used in the nutrient delivery system disclosed herein provide combinations of casein, pea, and rice protein that provide a complete source of essential amino acids, while also providing proteins that provide improved mineral uptake. In some embodiments, changes in the concentrations of the mineral binding proteins can be made within the general disclosed parameters to address needs for individual amino acids while maintaining the overall amino acid concentrations above the FAO minima. For example, in some embodiments, the relative concentrations of the binding proteins are varied to produce a lysine concentration of 57 mg/g of protein to 79 mg/g of protein.

[0017] To allow effective utilization of the calcium, zinc, and iron present in the nutrient delivery system, it is preferred that the minerals be present in the nutrient delivery system in an appropriate concentration relative to the respective binding proteins and relative to each other. Any effective weight ratio of the binding proteins to the minerals may be used. For example, effective utilization of calcium occurs when the calcium binding protein and the calcium are present in a weight ratio of 13:1 to 25:1, effective utilization of zinc occurs when the zinc binding protein and the zinc are present in a weight ratio of 6:1 to 900:1, and effective utilization of iron occurs when the iron binding protein and the iron are present in a weight ratio of 5.4:1 to 800:1. Surprisingly, as shown in Example 8, concentrations of one mineral can affect the uptake of another mineral. Thus, development of an overall nutrient delivery system involves consideration of the relative relationships between all of the mineral binding proteins and all of the minerals. Overall nutrient delivery systems based on the combination of relative binding proteins and the respective minerals are shown in Table 3 in the Examples section.

### **Product Form**

[0018] The nutrient delivery system may be formulated in any known or otherwise suitable product form for oral or parenteral administration. Oral product forms are generally preferred and include any solid, liquid, or powder formulation suitable for use herein, provided that such a formulation allows for safe and effective oral delivery of the essential and other selected ingredients from the selected product form. In some embodiments, the nutrient delivery system is provided in the form of a standalone supplement. In other embodiments, the nutrient delivery system is included as part of a nutritional composition. Where the nutrient delivery system is part of a nutritional composition, it can be provided in any suitable solid or liquid form that allows for effective delivery of the nutrient delivery system.

[0019] Non-limiting examples of suitable solid nutritional compositions include snack and meal replacement products, including those formulated as bars, sticks, cookies, breads, cakes, or other baked goods, frozen liquids, candy, breakfast cereals, reconstitutable powders, granulated solids, or other particulates, snack chips or bites, and frozen or retorted entrees.

[0020] Non-limiting examples of liquid product forms suitable for use herein include snack and meal replacement products, hot or cold beverages, carbonated or non carbonated beverages, juices or other acidified beverages, milk or soy-based beverages, shakes, coffees, teas, and enteral feeding compositions. These liquid compositions are most typically formulated as suspensions or emulsions, but can also be formulated in any other suitable forms such as clear liquids, substantially clear liquids, solutions, and liquid gels.

[0021] Other non-limiting examples of suitable oral product forms include semi-solid or semi-liquid compositions (*e.g.*, puddings, gels), as well as more conventional product forms such as capsules, tablets, caplets, and pills.

**Macronutrients**

[0022] In some embodiments, the nutritional compositions include at least one of a carbohydrate and a fat source. Any suitable carbohydrate, fat source, or both, may be included as part of the nutritional compositions.

[0023] Suitable carbohydrate sources include, but are not limited to, maltodextrin, hydrolyzed or modified starch or cornstarch, glucose polymers, corn syrup, corn syrup solids, rice-derived carbohydrates, high fructose corn syrup, honey, sugar alcohols, maltitol, erythritol, sorbitol, glycerine, sucrose, glucose, fructose, lactose, isomaltulose, sucromalt, pullulan, potato starch, and other slowly-digested carbohydrates, oligosaccharides including fructo-oligosaccharides, oat fiber, soy fiber, gum arabic, sodium carboxymethylcellulose, methylcellulose, guar gum, gellan gum, locust bean gum, konjac flour, hydroxypropyl methylcellulose, tragacanth gum, karaya gum, gum acacia, chitosan, arabinogalactans, glucomannan, xanthan gum, alginate, pectin, low and high methoxy pectin, cereal beta-glucans, carrageenan and psyllium; soluble dietary fibers including digestion resistant maltodextrins, resistant modified food starches, other resistant starches, soluble and insoluble fibers derived from fruits or vegetables, and combinations thereof.

[0024] Suitable fat sources include, but are not limited to, coconut oil, fractionated coconut oil, soy oil, corn oil, olive oil, safflower oil, high oleic safflower oil, medium chain triglyceride oil, high gamma linolenic safflower oil, sunflower oil, high oleic sunflower oil, palm oil, palm kernel oil, palm olein, canola oil, marine oils, algal oils, cottonseed oils, interesterified oils, transesterified oils, and combinations thereof.

[0025] In addition to the desired concentration of each of the nutrient delivery system's components within the delivery system, when the delivery system is part of a nutritional composition, the nutritional composition may be further characterized by the relative contribution of each component of the delivery system within the composition. For example, where the nutrient delivery system is part of a nutritional composition, the

nutritional composition desirably contains one or more of 0.05% to 1.0% calcium, 0.001% to 0.020% zinc, and 0.0005% to 0.050% iron, each by weight of the nutritional composition.

[0026] In those embodiments where the nutritional composition includes carbohydrate and fat in addition to the nutrient delivery system, it is preferred that the composition include 1% to 20% protein, including 1% to 12% protein, 1% to 60% carbohydrate, including 1% to 30% carbohydrate, and 0.1% to 12% fat, by weight of the nutritional composition.

### **Methods of Manufacture**

[0027] Nutritional compositions which include the nutrient delivery system may be manufactured by any known or otherwise suitable method for making nutritional compositions including nutritional liquids such as emulsions.

[0028] In one suitable manufacturing process, a nutritional liquid is prepared using at least three separate slurries, including a protein-in-fat (PIF) slurry, a carbohydrate-mineral (CHO-MIN) slurry, and a protein-in-water (PIW) slurry. The PIF slurry is formed by heating and mixing the selected oils (*e.g.*, canola oil, corn oil, fish oil) and then adding an emulsifier (*e.g.*, lecithin), fat soluble vitamins, and a portion of the total protein (*e.g.*, milk protein concentrate) with continued heat and agitation. The CHO-MIN slurry is formed by adding with heated agitation to water: minerals (*e.g.*, potassium citrate, dipotassium phosphate, sodium citrate), trace and ultra trace minerals (TM/UTM premix), thickening or suspending agents (*e.g.*, Avicel, gellan, carrageenan), and the nutrient delivery system. The resulting CHO-MIN slurry is held for 10 minutes with continued heat and agitation before adding additional minerals (*e.g.*, potassium chloride, magnesium carbonate, potassium iodide) and carbohydrates (*e.g.*, fructooligosaccharide, sucrose, corn syrup). The PIW slurry is then formed by mixing with heat and agitation the remaining protein (*e.g.*, sodium caseinate, soy protein concentrate) into water.

[0029] The resulting slurries are then blended together with heated agitation and the pH adjusted to the desired range, typically from 6.6-7.0, after which the composition is subjected to high-temperature short-time (HTST) processing during which the composition is heat treated, emulsified and homogenized, and then allowed to cool. Water soluble vitamins and ascorbic acid are added, the pH is again adjusted to the desired range if necessary, flavors are added, and water is added to achieve the desired total solid level. The composition is then aseptically packaged to form an aseptically packaged nutritional emulsion, or the composition is added to retort stable containers and then subjected to retort sterilization to form retort sterilized nutritional emulsions.

[0030] The nutritional solid, such as a spray dried nutritional powder or dry-mixed nutritional powder, may be prepared by any collection of known or otherwise effective techniques, suitable for making and formulating a nutritional powder.

[0031] For example, when the nutritional powder is a spray dried nutritional powder, the spray drying step may likewise include any spray drying technique that is known for or otherwise suitable for use in the production of nutritional powders. Many different spray drying methods and techniques are known for use in the nutrition field, all of which are suitable for use in the manufacture of spray dried nutritional powders.

[0032] The manufacturing processes for the nutritional powders may be carried out in ways other than those set forth herein without departing from the spirit and scope of the present disclosure. The present embodiments are, therefore, to be considered in all respects illustrative and not restrictive and that all changes and equivalents also come within the description of the present disclosure.

## **EXAMPLES**

[0033] The following examples illustrate specific embodiments and/or features of the present disclosure. The examples are given solely for the purpose of illustration and are not to be construed as limitations of the present disclosure, as many variations thereof are possible without departing from the spirit and scope of the disclosure. All

exemplified amounts are weight percentages based upon the total weight of the product, unless otherwise specified.

Table 2. Examples of protein systems, with concentrations as mg/g protein

| <b>Essential amino acid</b> | <b>FAO minimum</b> | <b>Ex. 1<br/>Protein = 70%<br/>casein, 15% pea,<br/>15% rice</b> | <b>Ex. 2<br/>Protein = 60%<br/>casein, 20%<br/>pea, 20% rice</b> | <b>Ex. 3<br/>Protein =<br/>50% casein,<br/>25% pea,<br/>25% rice</b> |
|-----------------------------|--------------------|------------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------|
| His                         | 20                 | 27                                                               | 26                                                               | 25                                                                   |
| Ile                         | 32                 | 51                                                               | 49                                                               | 48                                                                   |
| Leu                         | 66                 | 88                                                               | 86                                                               | 83                                                                   |
| Lys                         | 57                 | 71                                                               | 68                                                               | 65                                                                   |
| Met + Cys                   | 27                 | 32                                                               | 32                                                               | 31                                                                   |
| Phe + Tyr                   | 52                 | 101                                                              | 99                                                               | 96                                                                   |
| Thr                         | 31                 | 40                                                               | 38                                                               | 37                                                                   |
| Trp                         | 8.5                | 12                                                               | 12                                                               | 12                                                                   |
| Val                         | 43                 | 65                                                               | 63                                                               | 61                                                                   |

Table 3. Examples of effective nutrient delivery systems

|                                          | <b>Ex. 4</b> | <b>Ex. 5</b> | <b>Ex. 6</b> |
|------------------------------------------|--------------|--------------|--------------|
| Calcium, mg per 8-oz. serving            | 250          | 300          | 280          |
| Zinc, mg per 8-oz. serving               | 1.5          | 3.8          | 3.8          |
| Iron, mg per 8-oz. serving               | 2.7          | 4.5          | 4.5          |
| Protein, g per 8-oz. serving             | 7.0          | 8.8          | 13           |
| Casein protein, g per 8-oz. serving      | 4.9          | 5.3          | 6.5          |
| Rice protein, g per 8-oz. serving        | 1.0          | 1.7          | 3.2          |
| Pea protein, g per 8-oz. serving         | 1.1          | 1.8          | 3.3          |
| Casein:rice:pea (wt. % of total protein) | 70:14:16     | 60:19:21     | 50:25:25     |
| Casein protein:Ca, w/w                   | 19:1         | 17:1         | 23:1         |

|                         |       |       |       |
|-------------------------|-------|-------|-------|
| Rice protein:Zn,<br>w/w | 660:1 | 440:1 | 840:1 |
| Pea protein:Fe, w/w     | 400:1 | 400:1 | 730:1 |

**EXAMPLE 7: A mixture of peas and rice provides enhanced iron solubility relative to rice alone, at a constant total weight.**

[0034] Blends with varying proportions of rice (Dynasty brand jasmine rice) and green split peas (Giant Eagle brand), each containing Maplegrove Ultra Rice® at 0.5% (w/w), were tested for *in vitro* soluble iron as previously described (Food Anal. Methods (2014) 7: 902-911). The iron contributed by the Ultra Rice® was approximately 7 mg/100 g for each blend, in the form of micronized ferric pyrophosphate (mFePP). The results are shown in table 4, below. As shown in Table 4, the green split pea component, even at <10% of the blend, had a substantial enhancing effect on iron solubility.

Table 4. Effect of pea addition on iron solubility

| Sample | Rice/Pea blend,<br>w/w (Dynasty<br>jasmine rice and<br>Giant Eagle green<br>split peas) | mFePP added<br>as Maplegrove<br>Ultra Rice®, mg<br>per 100 g of<br>blend | Soluble iron,<br>mg/100 g of<br>blend |
|--------|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------|
| A      | 100/0                                                                                   | 7.05                                                                     | 0.094                                 |
| B      | 91/9                                                                                    | 7.11                                                                     | 0.530                                 |
| C      | 84/16                                                                                   | 7.12                                                                     | 0.800                                 |
| D      | 77/23                                                                                   | 6.93                                                                     | 0.824                                 |
| E      | 67/33                                                                                   | 6.99                                                                     | 0.958                                 |
| F      | 60/40                                                                                   | 7.18                                                                     | 0.997                                 |
| G      | 49/51                                                                                   | 6.96                                                                     | 1.055                                 |

**EXAMPLE 8: Zinc interferes with iron solubility at a constant iron concentration.**

[0035] Jasmine rice milled with 1.00% (w/w) Usher Agro Ultra Rice®, with and without (excess) added ZnO, was tested for soluble iron after an *in vitro* gastrointestinal (Gil) assay as previously described (Food Anal. Methods (2014) 7: 902-911). The control was tested in duplicate, and each Usher Agro blend was tested in triplicate. The soluble iron contribution from the reagents (buffers and enzymes) was subtracted in each case. The 1.00% Usher Agro blends are expected to contain total zinc at 1.09 mg/100 g (w/o ZnO addition), 33.2 mg/100 g (w/ ZnO addition), and total iron at 16.2 mg/100 g. The soluble iron concentrations are reported in Table 5 below. As shown in Table 5, in the presence of a constant concentration of iron, the addition of zinc decreased the amount of soluble iron.

Table 5: Effect of zinc on iron solubility.

| <b>Rice Blend</b>                                 | <b>Total Iron (mg/100g)</b> | <b>Fe/Zn Molar Ratio</b> | <b>Soluble Iron (mg/100g)</b> | <b>Soluble Iron (% of total iron)</b> |
|---------------------------------------------------|-----------------------------|--------------------------|-------------------------------|---------------------------------------|
| Jasmine rice w/ 1.00% Usher Agro #3               | 16.2                        | 17.4                     | 0.567 ± 0.042                 | 3.5 ± 0.3                             |
| Jasmine rice w/ 1.00% Usher Agro #3 and 0.04% ZnO | 16.2                        | 0.571                    | 0.052 ± 0.003                 | 0.32 ± 0.02                           |

[0036] Unless otherwise indicated herein, all sub-embodiments and optional embodiments are respective sub-embodiments and optional embodiments to all embodiments described herein. While the present application has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the application, in its broader aspects, is not limited to the specific details, the representative compositions or formulations, and illustrative examples shown and described. Accordingly, departures

may be made from such details without departing from the spirit or scope of the applicant's general disclosure herein.

## WHAT IS CLAIMED IS:

1. A nutrient delivery system comprising:  
a protein system, calcium, zinc, and iron;  
wherein the protein system comprises a calcium binding protein in an amount of 40% to 75% by weight of the protein system, a zinc binding protein in an amount of 10% to 30% by weight of the protein system, and an iron binding protein in an amount of 10% to 30% by weight of the protein system;  
wherein a weight ratio of the calcium binding protein to the calcium in the nutrient delivery system is 13:1 to 25:1;  
wherein a weight ratio of zinc binding protein to zinc in the nutrient delivery system is 6:1 to 900:1;  
wherein a weight ratio of iron binding protein to iron in the nutrient delivery system is 5.4:1 to 800:1.
2. The nutrient delivery system of claim 1, wherein the calcium binding protein is casein.
3. The nutrient delivery system of claim 1, wherein the zinc binding protein is rice protein.
4. The nutrient delivery system of claim 1, wherein the iron binding protein is pea protein.
5. The nutrient delivery system of claim 2, wherein the casein is present in an amount of 50% to 70% by weight of the protein system.
6. The nutrient delivery system of claim 3, wherein the rice protein is present in an amount of 15% to 25% by weight of the protein system.
7. The nutrient delivery system of claim 4, wherein the pea protein is present in an amount of 15% to 25% by weight of the protein system.
8. The nutrient delivery system of any preceding claim, wherein the protein system comprises casein in an amount of 50% to 70% by weight of the protein system, rice protein in an amount of 15% to 25% by weight of the protein system, and pea protein in an amount of 15% to 25% by weight of the protein system.

9. A nutritional composition comprising the nutrient delivery system of any preceding claim.
10. The nutritional composition of claim 9, wherein the nutritional composition is in the form of a liquid, a reconstitutable powder, or a bar.
11. The nutritional composition of claim 9 or 10, further comprising at least one of carbohydrate and fat.
12. The nutritional composition of any one of claims 9 to 11, wherein the concentration of lysine is 57 mg/g to 79 mg/g of protein in the nutritional composition.
13. The nutritional composition of any one of claims 9 to 12, wherein the nutritional composition meets the 2013 minimum protein quality requirements for adults established by the Food and Agriculture Organization of the United Nations.
14. A liquid nutritional composition comprising:
  - a protein system, calcium, zinc, and iron,
  - wherein the protein system comprises casein in an amount of 40% to 75% by weight of the protein system, rice protein in an amount of 10% to 30% by weight of the protein system, and pea protein in an amount of 10% to 30% by weight of the protein system;
  - wherein a weight ratio of the casein to the calcium in the liquid nutritional composition is 13:1 to 25:1;
  - wherein a weight ratio of the rice protein to the zinc in the liquid nutritional composition is 6:1 to 900:1; and
  - wherein a weight ratio of the pea protein to the iron in the liquid nutritional composition is 5.4:1 to 800:1.
15. The liquid nutritional composition of claim 14, wherein a total protein amount is 1% to 12% by weight of the liquid nutritional composition.
16. The liquid nutritional composition of claim 14, further comprising at least one of carbohydrate and fat.
17. The liquid nutritional composition of claim 14, wherein the casein is present in an amount of 50% to 70% by weight of the protein system.

18. The liquid nutritional composition of any one of claims 14 to 17, wherein the rice protein is present in an amount of 15% to 25% by weight of the protein system.
19. The liquid nutritional composition of any one of claims 14 to 18, wherein the pea protein is present in an amount of 15% to 25% by weight of the protein system.
20. The liquid nutritional composition of any one of claims 14 to 19, wherein the protein system comprises casein in an amount of 50% to 70% by weight of the protein system, rice protein in an amount of 15% to 25% by weight of the protein system, and pea protein in an amount of 15% to 25% by weight of the protein system.
21. The liquid nutritional composition of claim 20, wherein protein is present in an amount of 1% to 12% by weight of the liquid nutritional composition, carbohydrate is present in an amount of 1% to 30% by weight of the liquid nutritional composition, and fat is present in an amount of 0.1% to 12% by weight of the liquid nutritional composition.
22. The liquid nutritional composition of claim 20, wherein the calcium is present in an amount of 0.05% to 1.0% by weight of the liquid nutritional composition.
23. The liquid nutritional composition of claim 20, wherein the zinc is present in an amount of 0.001% to 0.020% by weight of the liquid nutritional composition.
24. The liquid nutritional composition of claim 20, wherein the iron is present in an amount of 0.0005% to 0.050% by weight of the liquid nutritional composition.
25. The liquid nutritional composition of any one of claims 14 to 24, wherein the concentration of lysine is 57 mg/g to 79 mg/g of protein in the liquid nutritional composition.

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2015/039381

A. CLASSIFICATION OF SUBJECT MATTER  
INV. A23L1/305 A23L2/66 A23L1/304  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
A23L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data, BIOSIS, FSTA

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                        | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2012/145346 A2 (NESTEC SA [CH]; ROY MARIE GEORGINA [FR]; GEOFFROY GILBERT [CH]; HAILE) 26 October 2012 (2012-10-26) paragraphs [0081], [0086]<br>----- | 1-25                  |
| X         | WO 2013/138906 A1 (WRIGHT JENNIFER [CA]; SPRAGUE DAVID [CA]) 26 September 2013 (2013-09-26) claims 3,7<br>-----                                           | 1-25                  |
| X         | WO 2013/167983 A1 (NESTEC SA [CH]) 14 November 2013 (2013-11-14) paragraphs [0071], [0078]<br>-----                                                       | 1-25                  |
| X         | US 2013/129868 A1 (GUELSEREN IBRAHIM [CA] ET AL) 23 May 2013 (2013-05-23) claims 1,3,5<br>-----<br>-/-                                                    | 1-25                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

1 September 2015

Date of mailing of the international search report

09/09/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040,  
Fax: (+31-70) 340-3016

Authorized officer

Merk1, Bernhard

## INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/039381

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                               | Relevant to claim No. |
|-----------|------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | US 2006/280840 A1 (ROBERTSON MARION G [US]) 14 December 2006 (2006-12-14)<br>paragraph [0304]; claim 23<br>----- | 1-25                  |
| X         | US 2013/344010 A1 (POMPEJUS MARKUS [US])<br>26 December 2013 (2013-12-26)<br>paragraph [0320]<br>-----           | 1-25                  |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/039381

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Publication<br>date                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WO 2012145346 A2                          | 26-10-2012          | AU 2012245611 A1<br>CA 2831798 A1<br>CN 103491802 A<br>EP 2699102 A2<br>JP 2014513527 A<br>RU 2013151680 A<br>SG 193967 A1<br>US 2014093609 A1<br>WO 2012145346 A2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 17-10-2013<br>26-10-2012<br>01-01-2014<br>26-02-2014<br>05-06-2014<br>27-05-2015<br>29-11-2013<br>03-04-2014<br>26-10-2012                                                                                                                                                                                                                                                                                                                                                                                                         |
| WO 2013138906 A1                          | 26-09-2013          | AU 2013234830 A1<br>CN 104302193 A<br>EP 2897471 A1<br>PH 12014502320 A1<br>US 2015079235 A1<br>WO 2013138906 A1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 06-11-2014<br>21-01-2015<br>29-07-2015<br>12-01-2015<br>19-03-2015<br>26-09-2013                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| WO 2013167983 A1                          | 14-11-2013          | AU 2013216671 A1<br>AU 2013216680 A1<br>AU 2013219203 A1<br>AU 2013219204 A1<br>CN 103517640 A<br>CN 103517641 A<br>CN 103517642 A<br>CN 103648298 A<br>CR 20130411 A<br>EP 2675290 A1<br>EP 2675291 A1<br>EP 2675292 A1<br>EP 2675293 A1<br>JP 2014515617 A<br>JP 2014515618 A<br>JP 2014515619 A<br>JP 2014516563 A<br>PE 06352014 A1<br>PE 07292014 A1<br>PE 07312014 A1<br>PE 09712014 A1<br>RU 2013151075 A<br>RU 2013151076 A<br>RU 2013151078 A<br>RU 2013151080 A<br>SG 194426 A1<br>SG 194428 A1<br>SG 194429 A1<br>TW 201345435 A<br>US 2013115329 A1<br>US 2013115330 A1<br>US 2013122139 A1<br>US 2013122148 A1<br>WO 2013167980 A1<br>WO 2013167981 A1<br>WO 2013167982 A1<br>WO 2013167983 A1 | 21-11-2013<br>21-11-2013<br>21-11-2013<br>21-11-2013<br>15-01-2014<br>15-01-2014<br>15-01-2014<br>19-03-2014<br>08-01-2014<br>25-12-2013<br>25-12-2013<br>25-12-2013<br>25-12-2013<br>03-07-2014<br>03-07-2014<br>03-07-2014<br>17-07-2014<br>06-06-2014<br>15-07-2014<br>15-07-2014<br>15-08-2014<br>27-05-2015<br>20-05-2015<br>20-05-2015<br>27-05-2015<br>30-12-2013<br>30-12-2013<br>30-12-2013<br>16-11-2013<br>09-05-2013<br>09-05-2013<br>16-05-2013<br>16-05-2013<br>14-11-2013<br>14-11-2013<br>14-11-2013<br>14-11-2013 |
| US 2013129868 A1                          | 23-05-2013          | NONE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| US 2006280840 A1                          | 14-12-2006          | NONE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/039381

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date         |
|-------------------------------------------|---------------------|----------------------------|-----------------------------|
| US 2013344010                             | A1                  | 26-12-2013                 | CA 2819794 A1 02-08-2012    |
|                                           |                     |                            | CN 103384526 A 06-11-2013   |
|                                           |                     |                            | EP 2667883 A1 04-12-2013    |
|                                           |                     |                            | JP 2014508136 A 03-04-2014  |
|                                           |                     |                            | KR 20140000710 A 03-01-2014 |
|                                           |                     |                            | RU 2013139217 A 10-03-2015  |
|                                           |                     |                            | US 2013344010 A1 26-12-2013 |
|                                           |                     |                            | WO 2012100991 A1 02-08-2012 |